

Running head: A MATTER OF PRIORITY: DEVELOPING A DECISION-MAKING

A Matter of Priority: Developing a Decision-Making Matrix
for the Modification of Staffing Levels

Dwight N. Good

Merced Division

Madera, Mariposa, Merced (MMU) Ranger Unit

California Department of Forestry and Fire Protection (CAL FIRE)

Appendices Not Included. Please visit the Learning Resource Center on the Web at <http://www.lrc.dhs.gov/> to learn how to obtain this report in its entirety through Interlibrary Loan.

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: _____

A handwritten signature in black ink, written over a horizontal line. The signature is stylized and cursive, appearing to read "Robert A. [unclear]".

Abstract

This paper was intended to develop and produce a decision matrix that can be used to prioritize incremental staffing increases or decreases among engine companies. In the absence of industry consensus standards or guidelines on the issue, action research and questionnaires were used to determine what the components of a decision matrix were, and what, if any, decision models other fire departments were using for staffing modifications. The components identified in this process were: risk assessment, special projects, socioeconomic risk indicators, speed and weight of response, firefighter injury rates, demand zones, and apparatus utilization.

A micro-analysis was conducted, and the results were analyzed to determine which variables and combinations of sub-components were appropriate for the decision matrix, and to determine appropriate values or weights for each of them. A combination of 15 sub-components were evaluated for statistical relevance, and assigned to 4 variable groups. Variables were analyzed through multiple regression and correlation studies. A simplified version of statistical bootstrapping was used to determine the relative value of each subcomponent.

The final product was an Excel-spreadsheet program that can be used to prioritize staffing level modifications based on a combination of risk and workload indicators.

Table of Contents

Abstract.....p. 3

Introduction.....p. 6

Background and Significance.....p. 7

Literature Review.....p. 11

Procedures.....p. 21

Results.....p. 32

Discussion.....p. 37

Recommendations.....p. 44

References.....p. 46

Appendixes

Appendix Ap. 51

Appendix Bp. 52

Appendix Cp. 53

Appendix Dp. 56

Appendix Ep. 66

Appendix Fp. 67

Appendix Gp. 68

Appendix Hp. 78

Appendix Ip. 80

Appendix Jp. 82

Appendix Kp. 92

Appendix Lp. 95

Appendix Mp. 96

Appendix Np. 99

Appendix Op. 101

Appendix Pp. 102

Appendix Qp. 103

Appendix R.....p. 123

A Matter of Priority: Developing a Decision-Making Matrix for the Modification of Staffing Levels

INTRODUCTION

The problem is that the Merced County Fire Department is increasing Engine Company staffing levels in an incremental fashion.

The purpose of this research is to develop and produce a decision-making matrix that can be used to prioritize staffing increases among the Division's twenty-one companies.

Research questions include:

- 1) What are the components of a decision-making matrix?
- 2) What, if any, decision making models are departments similar in size to Merced County Fire Department using for staffing modifications?
- 3) What value or weight should be assigned to each component of the decision-making matrix?
- 4) What combination of these components and respective values will accurately identify the most effective use of available staffing?

These questions will be answered through the use of Action research, questionnaires, and statistical analysis.

BACKGROUND AND SIGNIFICANCE

The Merced County Fire Department (MCFD) is a full service fire department providing emergency services to all unincorporated areas of the County, and to the Cities of Dos Palos, Gustine, and Livingston through contractual agreements. The primary mission of the MCFD is to protect the lives, environment, and property, of Merced County's residents from the adverse effects of fires, medical emergencies, exposure to hazardous materials, and other dangerous conditions. (Merced County Fire Department [MCFD], 2004)

The MCFD performs fire protection planning, fire prevention education, code and enforcement functions. Additional services include fire suppression, rescue and extrication, control and mitigation of Hazardous Materials (HAZMAT) emergency incidents, Aircraft Rescue Firefighting (ARFF), and Emergency Medical Services (EMS) at the first responder level. The MCFD also provides mutual and automatic aid to cooperating local agencies and participates in the statewide fire and rescue mutual aid system. (MCFD, 2004)

Goals of the MCFD include: providing integrated, cooperative, and cost-effective fire protection and emergency services to the public; the continual improvement of operational efficiency and fiscal accountability, increased professionalism, and support of the mission, goals, and objectives of the Merced County government. (MCFD, 2004)

The MCFD's administrative and suppression personnel have been provided through a contract with Cal Fire – formerly the California Department of Forestry and Fire Protection (CDF) – since 1988 (Scott Newman, personal communication, August 17, 2009). Over the last eight years, the MCFD has averaged just over 7,700 calls annually (Merced County Workload Indicators, n.d.). On a larger scale, the MCFD operates as the Merced Division of the Madera,

Mariposa, Merced (MMU) Ranger Unit of Cal Fire, the largest Fire Department in the state of California, and the third largest Fire Department in the United States (CDF Firefighters, n.d.).

Merced County is a primarily agrarian central San Joaquin Valley area, covering approximately 2,000 square miles. Government and agriculture are the two largest employers. The seasonal nature of agriculture leaves Merced County with some of the highest unemployment and poverty rates in California. Merced County's population is also below the State average for education levels. (MCFD, 2004)

The Insurance Services Office (ISO) rates fire departments and assigns public protection classifications for the establishment of fire insurance rates. Higher ISO rating numbers indicate lower levels of service and higher costs for fire insurance. The ISO ratings for Merced County are Level 5 for areas with fire hydrants. Areas without hydrants, but within five miles of a fire station are assigned Level 8. The remainder of the County has an ISO rating of 9. (MCFD, 2004) For reference, an area with no organized fire protection services is assigned a rating of 10.

A combination department with 21 fire stations, the MCFD has traditionally staffed each of their stations 24 hours a day with one full-time career Fire Captain or Fire Apparatus Engineer, and relied on paid-call firefighters (PCFs) for supplemental staffing. Generally, PCFs are assigned to the engine company closest to their home or place of employment. Merced County's fire station response areas vary in size from 16 to 325 square miles. (MCFD, n.d.; MCFD, 2004)

Four of these stations are currently staffed with 2 career personnel at all times, and the MCFD intends to increase minimum daily staffing levels at the remaining stations from 1 to 2 career personnel. These staffing increases are being driven partly by firefighter safety concerns, and partly to improve efficiency at the station level. The move also reflects a change in agency

policy: Cal Fire requires minimum staffing levels of at least 2 personnel in all new contracts. However, budgetary constraints will not allow the MCFD to assign a second person to each station in a single budget cycle. As a result, these staffing increases will occur over several years, and in small annual increments. (Scott Newman, personal communication, August 17, 2009; Bob Wallen, personal communication, August 21, 2009)

In the absence of guidelines based on accepted professional standards, staffing increases have been determined – to this point – primarily on call volume and PCF response at each respective station. Merced Division Chief Scott Newman assigned this author the tasks of: determining if a better decision making model exists, and producing a working decision making model for future staffing decisions, with justifications that can be clearly articulated to the Merced County governing body. To that end, Division Chief Newman suggested the inclusion of a risk analysis program such as RHAVE (2001), and a review of the fire service accreditation process. (Scott Newman, personal communications)

Because Cal Fire is currently managing 145 separate cooperative fire protection agreements across the state of California, including 34 other county fire departments, this research project may be beneficial to this author's organization, and have statewide impacts. (Cal Fire, n.d., Local Government section)

Only two of the twenty agencies that originally responded to a questionnaire on the topic had a decision model in place for incremental staffing increases, although four had one for staffing decreases. As fire departments across the nation continue the trends of consolidation and downsizing, this project may be beneficial to an ever-expanding portion of the American fire service. Logic suggests that a decision-making matrix designed to prioritize staffing increases at the station level could also be used in the inverse.

This project relates to Units 3, 6, 7, 8 and 10 in the Executive Development course offered at the National Fire Academy (NFA) as the first year component of the Executive Fire Officer Program (EFOP). Unit 3 includes a discussion on the *Analysis, Planning, Implementation, and Evaluation* (APIE) change model which was applied during this study, and which will be used during implementation of the decision matrix (Appendix A). Unit 6 is committed to change and creativity in the organizational setting. Unit 7 explores the relationships between organizational culture and change. Unit 8 is dedicated to ethics and change, with a section committed to the process of shaping and reinforcing organizational values. This unit also challenges the reader to compare the stated values of one's organization against those observed in the organizational culture. Unit 10 is dedicated to service quality, with a discussion of the fire service self-assessment model included in the Appendix that follows.

This topic also relates to three of the five United States Fire Administration (USFA) *Strategic Goals*. Specifically, numbers two, three, and four, as this project should “improve local planning and preparedness,” “improve the fire and emergency services’ capability for response to and recovery from all hazards,” and “improve the fire and emergency services’ professional status.” (USFA, 2009, Strategic Plan section)

LITERATURE REVIEW

A review of the literature revealed no clear consensus, and confirmed Division Chief Newman's assertion that no accepted industry standard had been established in this area. This is discouraging in light of the decades of discussion and debate that have occurred within the American fire service on the issue of appropriate staffing levels. George A. Glenn II (1990) and Bruce H. Allcott (1991) both reported a vacuum in the area of qualitative research on Engine Company staffing levels.

What are the components of a decision-making matrix?

Sorach, Inc. (2000) identified the components of a decision matrix as: (a) context, (b) objective, (c) options, and (d) criteria. In a decision matrix, key elements are identified and weighted numerically and total scores are used to highlight the most viable or least viable options (Time-Management-Guide.com, 2005). The following paragraphs identify the key elements appropriate and necessary for the development of a staffing decision matrix.

Research conducted at the Learning Resource Center on the National Fire Academy (NFA) campus uncovered an older round table discussion in *Fire Engineering Magazine*, which was included here for historical reference. In the March, April, May, and June issues of 1969, chief officers from across the United States discussed the issue of proper staffing levels for engine and truck companies. In the May issue, Chief Gordon F. Vickery argued that "[saying] every engine company should have a certain number of men is the same as saying that every engine company should have the same assignment (p. 40)." In the June issue, Assistant Chief Vernon Armstrong listed the physical layout of a company's initial response area, and the time required to complete special projects assigned to a company as critical factors of the staffing decision (p. 34).

Risk Assessment Tools

In a February 1988 article in *Fire Chief Magazine*, then-Chief Deputy Director of CDF, Ronny J. Coleman, wrote about the *Risk, Hazard and Value Evaluation* (RHAVE) program while it was still in development, encouraging the American fire service to apply scientific principles to the discipline of fire science (p. 28). RHAVE was presented as “an indexing system... designed to provide a context for decisions (p. 33).” The program was intended to support fire departments in the development and evaluation of their individual *Standards of Response Cover* (Coleman, 2004, p. 34, para. 12).

This author obtained an original copy of RHAVE from the U.S. Fire Administration (USFA) Publications Center on the NFA campus in July 2009, although even in compatibility mode, the program does not work in a Microsoft Windows Vista operating system. RHAVE is no longer available from the USFA (USFA, 2009), and has not been supported its creators or original sponsors, including the Commission on Fire Accreditation International (CFAI). The program has not been updated since its release, and does not work on modern computer operating systems. To further aggravate the issue, RHAVE is still listed as a viable risk analysis tool in the latest edition of the International City/County Management Association’s publication *Managing Fire and Rescue Services* (2009, p. 40 – 41).

According to Dave Holmerud, a contract instructor for the NFA, RHAVE was revised in 2001 to reflect emerging Homeland Security issues, but was only available for a brief period of time before “they pulled the plug.” Holmerud had no other information about the demise of the program, but offered to send me a copy of his personal revision; an Excel-based spreadsheet derived from RHAVE 2.0 (Personal communication, August 25, 2009). Rick Black, from the Center for Public Safety Excellence (CPSE), reported that the trademark for the program, now

called VISION, was sold to a company called Emergency Reporting, and that CPSE is working on a new risk assessment tool that will be more “comprehensive and scientifically valid (Personal communication, September 9, 2009).”

Developed as a means to help “...make objective, quantifiable decisions about... fire and emergency services needs...,” and “[establish] standards of response coverage (NFA 2001, FA 213),” this author found the apparent abandonment of RHAVE even more discouraging than the staggering task of entering risk assessment data for an entire county (ICMA, 2009).

A 2008 publication from the United Kingdom’s (UK) Department for Communities and Local Government, entitled *Fire Service Emergency Cover (FSEC) Toolkit* (2008), describes a Geographic Information System (GIS) - based risk assessment program that calculates fire department response times and outcomes, in terms of property damage and loss of life (p. 3 & 4). Census data are imbedded in the software to reflect socio-economic conditions and population density. Historical fire data are also included to ensure the reliability of projected scenario outcomes, and to produce “risk maps,” identifying the highest risk areas in a community. Information about the “built environment” is obtained from local fire department pre-fire plan data (p. 7 & 8). The FSEC Toolkit can be used to evaluate the effects of various strategic proposals, including: changes to station locations, apparatus response plans, and staffing levels, at little cost, and without additional risk to the community served (p. 10). This program appears to have picked up where RHAVE left off, and uses many of the same risk assessment variables.

The authors defined Fire Service Emergency Cover as “the resource provided continuously ...to respond to any incident which is reasonably likely to occur, in order to keep the risk within tolerable bounds (The Fire Cover Review, 2002, p. 10).” In the same document, risk is defined as “the product of probability and consequence (p. 17, para. 1).”

Excited by the possibilities, this author requested additional information about the software. A response from the FSEC helpdesk brought up licensing issues. Also, since UK census and GIS data had been integrated into the program, it would not be useful for this research project (Jim Smith, personal communication, August 7, 2009).

Glenn (1990) listed the availability of outside assistance as an important variable in the engine company staffing decision process (p. iii), and cautioned against a risk assessment biased by a focus on the “rare, catastrophic event” (p. 9, para. 1) which would require “greater than normal staffing levels” (p. 3). A 2008 publication from the UK’s Department for Communities and Local Government Fire Research, discussing applications of their *Local Risk Assessment Guide* (LRAG) contained similar findings. In addition, Glenn (1990) listed: (a) local population, (b) population density, (c) local economic base, (d) building construction, (e) response times, and (f) response force capabilities, as variables that must be considered (p. 7).

On the issue of rare, catastrophic events, The International Association of Fire Chiefs (IAFC) *Chief Officer’s Desk Reference* (2006) suggests that although “the maximum and worst risks...” should be identified, “the frequency and probability of occurrence...” should be also considered (p. 90, para. 1). The CFAI (2003) manual argues that “The dilemma that any fire agency has is staffing for routine emergencies and being prepared for the fire of maximum effort (p. 83, para. 3).”

Socioeconomic Risk Indicators

The authors of *Socioeconomic Factors and the Incidence of Fire* (FEMA, 1997) reported that the four most significant components in fire rates were: (a) parental presence, (b) poverty, (c) unemployment, and (d) under-education (p. 3). The report also presents the argument that “socioeconomic and environmental factors outweigh fire suppression factors... in determining

losses from fires... [including] the dollar value of loss to property and the rate of injury and death (p. 7, para. 3)...” The authors also list two components useful in distinguishing fire risks in poor rural households from those of urban households:

[These] *communities ...are less ...able to afford the level of fire protection services ...available in urban areas. [There is also] a greater likelihood that [they] live in remote locations... These factors slow the response time of the fire department and may increase the extent of the loss caused by a fire.*

(p. 25, para 1)

A 2008 publication from the UK’s Department for Communities and Local Government, entitled *Analysis of Fire and Rescue Service Performance and Outcomes with Reference to Population Socio-Demographics* (2008), identified the socio-demographic indicators that were most closely associated with increased fire risk across that nation. Most significant were: (a) single-parent household, (b) single adult household, (c) employment rates, and to a lesser degree, (d) crime rates, (e) education levels, and (f) living environment (p. 8 & 9). The results are strikingly similar to those detailed in *Socioeconomic Factors and the Incidence of Fire* (FEMA, 1997): variations may be explained by a combination of cultural difference or by the difference of more than ten years between the two studies.

Speed and Weight of Attack

A 1995 International Association of Fire Fighters (IAFF) publication, *Safe Firefighter Staffing*, lists rapid response times and “sufficient numbers of personnel” as critical to limiting fire spread (p. 5, para. 1).

In a 1976 report to the NFPA prepared by the Mission Research Corporation, “structure type” and “surroundings” were listed as critical components in the study of relationships between

engine company staffing levels and structural fire suppression activities. Other critical components listed in the report were the fire department response, described as: "...response time..., ...quantity ...of each equipment type [responding]..., and the manning level of each equipment type... per response (p. 13, para. 2)." The authors also noted that "...although [arrival time] is not a function of manning levels, fire cost may be a strong function of [arrival time] (p. 17, para. 2)." This suggests that fire loss statistics may be an inappropriate indicator of the need for staffing increases where response times are extended. However, overall costs may be reduced if staffing increases result in reduced firefighter injury rates. (p. 34, para. 5)

Under the Insurance Services Office (ISO) *Fire Suppression Rating Schedule* (1980), PCFs are credited as personnel based on the average number responding on first alarm assignments, divided by three (p. 23, 570 B & 571). This may provide some guidance in the future calculations of the value of this supplemental manpower response.

Standards of Cover

In a February 2004 article in *Fire Chief* Magazine, Ronnie J. Coleman wrote about a Commission on Fire Accreditation International (CFAI) manual entitled *Creating & Evaluating Standards of Response Cover*: a publication designed to help fire departments establish deployment analysis criteria (p. 34, para. 11). The CFAI manual (2003) recommends identifying "demand zones," which may be based on historical call volume or influenced by data from local planning departments, developing community profiles, and determining what a community expects from their fire department (p. 14 & 15). CFAI (2003) also recommends performing a risk assessment, and utilizing a tool such as RHAVE. As an alternative, the authors suggest importing ISO risk analysis data into a GIS program (p. 26), and performing an EMS risk assessment based on historical call volume (p. 27). The authors note that the "...objective should be to find a

balance between distribution, concentration and reliability that will keep ...risk at a reasonable level, and at the same time yield the maximum savings of life and property at the least cost” (p. 61). Other factors identified in this document included: the amount of time a company is available and in quarters, and the interdependency of neighboring stations (p. 109 & 110).

The National Fire Protection Agency’s (NFPA) 1710: *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* (2004) provides response time objectives. Among them, four minutes or less for the arrival of the first engine company at a fire suppression incident or emergency medical incident ninety percent of the time (5.2.4.1.1). In the rural firefighting environment common to greater Merced County, this objective will likely remain out of reach. However, it may be useful as a limiting factor for the size and scope of future risk assessments initiated by the department. To satisfy the firefighting deployment requirements in this Standard, it is necessary to provide at least 12 personnel on the first alarm assignment (5.2.4.2.2).

Clinton R. Shelley (2008) listed: (a) “call volume,” (b) “response time,” (c) “out of service time,” (d) “growth and expansion” of response areas, (e) “other workload,” and (f) “direction from elected officials,” as critical factors for determining the need to increase the number of ambulances staffed in a jurisdiction (p. 20, para. 3 & p. 28, question 6). The International City/County Management Association (ICMA) publication *Managing Fire and Rescue Services* (2002) listed: the (a) population protected, (b) population density, (c) types of structures, (d) response distances, and (e) workload data, as variables to be considered in staffing decisions (p. 126).

The Value of a Single Firefighter

John Q. Webb (1994) pointed out that staffed engine companies in combination fire departments often arrive several minutes ahead of their responding PCFs. Even though that first few minutes at the scene often has the most influence on the outcome of an emergency incident, this staggered arrival data is not captured in incident reports. (p. 6) Webb (1994) asserted that using fewer firefighters to perform a task extends the time needed to complete the task and increases the chances of injury or death to firefighters and civilians, alike, concluding that even small increases in Engine Company staffing levels would shave minutes off of critical tasks (p. 7). Studying data from the Seattle Fire Department, Webb (1994) found that each additional firefighter assigned to an engine resulted in an injury rate decrease of 20 to 50 percent (p. 29).

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* (2007), lists risk identification, risk evaluation, and the establishment of priorities for action, as important components of a risk management plan (4.2.3). The Standard also provides a list of variables that should be considered during the decision making process, including: “...real and potential risks [to firefighters and the fire department] in terms of frequency and severity,” such as, “...cost, time lost from work, [and] loss of resources...” The Standard mandates the “[development of] effective control measures to ensure a safe work environment for all members...” (A.4.2.3)

J. Curtis Varone (1995) reported a 24 percent reduction in firefighter injuries when company staffing levels were increased from three to four personnel (p. 97, para 1). In *Emergency Incident Rehabilitation* (USFA, FEMA, 2008), the authors report that roughly “...half of all firefighter fatalities and a significant percentage of injuries... are as a result of

stress and overexertion... [during] emergency scene operations and training exercises (p. 1, para. 2).”

Michael J. Vatter (1998) reported an inverse relationship between staffing levels and firefighter injury rates; “as shift strength decreases, the number of injuries... can be expected to increase if all other variables remain unchanged (p. 19, para. 1).” In *Risk Management Practices in the Fire Service* (USFA, FEMA, 1996), the authors noted that fire departments must manage their organizational risks at the same time that they manage community risks (p. 23, para. 5).

In a January 2009 article in *Firehouse Magazine*, Deputy Chief William Goldfeder discussed a near-miss “firefighter down” incident. The problem of an inadequate number of personnel at the scene was identified as a contributing issue - the Incident Commander (IC) was overwhelmed, and only two personnel were assigned to the Rapid Intervention Team (RIT) (p. 31, para. 8 & p. 32, para. 6). In an August 2005 article in *Fire Engineering Magazine*, Chuck DeLuca argued that an “...understaffed engine company will only become a dangerously understaffed [RIT].” DeLuca asserted that the NFPA staffing requirement of two people is dangerously inadequate for a RIT, because five or six people are actually required for the safe and effective rescue of a firefighter in distress. (p. 30)

Offering alternative points of view, a March 2008 article in *Fire Rescue Magazine* by Chief I. David Daniels (p. 74, para. 10), and an April 2008 article in *Fire Engineering* by Paul J. Urbano (p. 58, para. 6), counter the argument that firefighting staffing levels should be couched as a safety issue. Daniels (2008) and Urbano (2008) assert that fire ground tactics and strategies should be based on what the personnel at scene can accomplish safely. Michael Allora offered a similar argument in a December 2003 Roundtable discussion in *Fire Engineering Magazine*: “Do the best you can with what you have. But make sure all of your firefighters go home at the end of

the day (p. 40, para. 4).” In the same article, Battalion Chief Danny Kistner cautioned: “We must be reasonable... and know our limitations. Where we fail is that we do not know our real capabilities (p. 42, para. 4).” The authors of *Risk Management Practices in the Fire Service* (1996) stated that “It is not acceptable... for fire departments to risk the lives of [their firefighters]... because they do not apply appropriate judgment in conducting emergency operations (p. 65, para. 2).”

Three Executive Fire Officer Program (EFOP, NFA) papers written in the early 1990s provided data from a series of timed company evolutions. Average reductions ranging from 23 to 31 percent were reported when a four-person company performed the same drill as a three-person company (Morrison, n.d., p. 12; Cooper, 1991, p. 11). Average reductions of 27 percent were reported when a three-person company performed the same evolution as a two-person company (Cooper, 1991, p. 11). Allcott (1991) reported that each additional firefighter had a significant impact on the effectiveness of operations (p. 13).

In a November 1960 article in *Fire Engineering Magazine*, William E. Clark reported on a series of timed firefighting evolutions performed by two, three, four, five, and six-person companies. Three-person companies completed the evolutions an average of 39 percent faster than two-person companies. Four-person companies completed the evolutions an average of 27 percent faster than three-person companies. Five-person companies completed the evolutions an average of 23 percent faster than four-person companies. (p. 1030 – 1033) This data suggests that each additional firefighter improved the performance of the company by about 30 percent. Although this research paper is not exploring the benefits of increasing minimum daily staffing levels from three to four personnel, the information provides some insight into the value of one additional firefighter.

PROCEDURES

Questionnaires were emailed to nearly 200 Federal, State, County and local government fire agencies with jurisdiction in the state of California - including this author's organization - asking them how staffing modification decisions were handled within their respective organizations (Appendix A). Responses were originally received from 20 agencies, including two Federal firefighting organizations, eight metropolitan fire departments, and one independent services district fire department.

What, if any, decision making models are departments similar in size to Merced County Fire Department using for staffing modifications?

Question 1: "Does your organization have a decision making model in place that could be used to determine which companies received additional personnel first?" (Appendix A)

Results: Only two of the responding agencies had a model to determine staffing increases, and one of those had not fully implemented it yet. Four had minimum staffing levels defined by Labor/Management agreement or Memorandum of Understanding (MOU).

Question 1a: "What components of risk or need does your organization use to make these decisions?" (Appendix A)

Results: Three of the responding agencies listed historical incident data. Three listed some form of elevated risk – either to responders, civilians, or property. Two of the responding agencies listed response times. Two listed call volume. Two listed apparatus hour use or availability. Two listed company workload, and one identified company-level leadership, training, and mentoring capabilities.

Question 2: "Does your organization have a decision making model in place that could be used to determine which companies were affected by staffing reductions first?" (Appendix A)

Results: Four of the responding agencies had a model used to determine staffing decreases. Four had minimum staffing levels defined by Labor/Management agreement.

Question 2a: “What components of risk or need does your organization use to make these decisions?” (Appendix A)

Results: Two of the responding agencies listed response times. Two listed historical incident data. Two listed a review of their Standards of Cover. Two listed coverage or adjoining or overlapping response areas. Other variables listed were: (a) apparatus hour use, (b) call volume, (c) company workload, (d) valuation, (e) population, and (f) simultaneous calls.

Question 3: “Which components would your organization view as most significant?” (Appendix A)

Results: Four of the responding agencies listed response times. Three listed overlapping or adjoining response areas, and three listed call volume, as components viewed as the most significant by their organizations when confronted with the staffing decision. Other variables listed were: (a) historical incident data, (b) company workload, (c) contractual obligations, and (d) risk analysis.

Question 3a: “Least significant?” (Appendix A)

Results: Four of the responding agencies listed political pressure – two from external sources, and two from within their agencies. Other variables listed were: (a) public relations events, (b) actual need, (c) perceived risks, (d) valuation, and (e) operational concerns.

Question 4: “Which components would you personally and professionally view as most significant?” (Appendix A)

Results: Five respondents listed call volume. Four listed response times. Four listed life safety. Two listed overlapping or adjacent response areas. Two listed risk assessment. Two listed environment and property conservation. One respondent listed company workloads.

Question 4a: “Least significant?” (Appendix A)

Results: Respondents listed (a) response distance, (b) public perception, (c) adjoining or overlapping response areas, (d) demographics, (e) valuation, and (f) contractual agreements.

Question 5: “How could those components be combined to prioritize staffing increases or decreases at the company level?” (Appendix A)

Results: None of the responding agencies suggested how these components could be combined in the staffing decision model. Four respondents identified the process of determining staffing level increases or decreases as complex.

This author conducted an experimental micro-analysis in an effort to determine the appropriate value or weight that should be assigned to each component of the staffing decision matrix, and which combination would accurately identify the most effective use of available staffing. This process was necessary in order to develop the decision matrix.

The components identified and discussed in the literature review, and gathered from the questionnaires were as follows: (a) risk assessment, (b) special projects, (c) socioeconomic risk indicators, (d) speed and weight of emergency response, (e) firefighter injury rates, (f) demand zones, and (g) apparatus utilization. These seven components were then broken down into sub components for further study.

Ten MCFD engine companies were selected for this project. In lieu of random selection, engine companies were selected in alphabetical order, based on the communities they serve:

Ballico, Castle, Cressey, Delhi, Dos Palos, Dos Palos Wye, El Nido, Franklin/Beachwood/McSwain, Gustine, and Hilmar. (Appendix B)

In a comparative analysis of MCFD engine companies by average annual call volume (Fig. 1), the 10 selected were evenly distributed: three of these stations were within in first quartile, three were within the third quartile, and the remaining four were near the median.

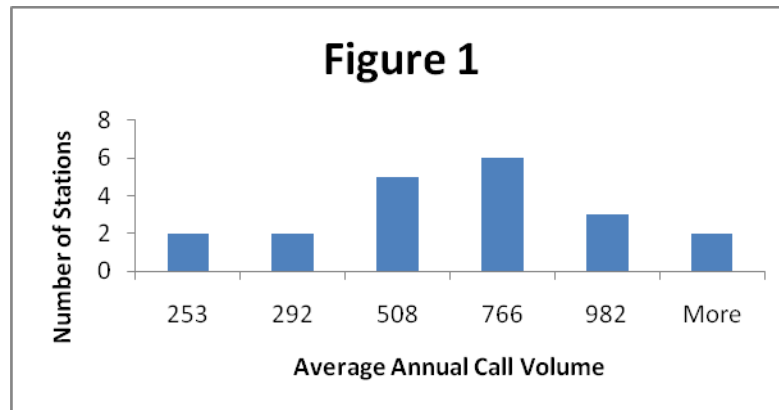


Fig. 1

To limit potential bias, these companies were only referred to by station number thereafter: 61, 62, 64, 74, 75, 76, 83, 91, 92, and 95. Companies 61 and 62 are currently staffed with 2 personnel. Company 62 does not have PCFs, but provides ARFF service at Castle Airport, and HAZMAT services for the entire County.

Risk Assessment

Risk assessments were conducted in a 2.5 mile radius around these 10 fire stations using Holmerud's Excel-based version of RHAVE (samples in Appendix C). All improved parcels within .25 mile of each station – as identified in the Merced County Association of Governments (MCAG) interactive GIS database – were included (Appendix D). This data was combined with information collected from the digital pre-fire plans available on the Cal Fire *Intranet* (n.d.) for occupancies within each 2.5 mile radius, and cross-referenced via *Google Maps* (n.d.). Assessed

valuations for a 2.5 mile radius around each station included in this study were obtained from the Merced County Planning Division.

Special Projects

The special projects component was defined by the estimated time committed annually to these projects at the station level. The MCFD does not have a comprehensive database where special projects or personnel hours committed to special projects is collected. Estimates were provided by the Battalion Chiefs responsible for each of the respective stations in this study. Because this data was unverifiable and the majority of special projects identified could be considered transferrable, this variable was excluded from further analysis.

Socioeconomic Risk Indicators

Socioeconomic risk indicators were pulled from the most recent U.S. Census Bureau *American Fact Finder Fact Sheet* (2000) statistics for each community, as identified by postal zip code (sample in Appendix E). Population figures were included to provide a reference point for the other data. Sub-components in this category include (a) parental presence, (b) poverty, (c) education, and (d) employment rates. The accumulated percentages of *High School* and *College Educated* in each community were used to determine the *Percentage Undereducated* in each community. *Unemployment* levels were determined by subtracting the *Percentage Employed* in each community from 100%. The accumulated percentages of *Individuals* and *Families Living below the Poverty Level* were used to determine the *Percentage in Poverty* in each community. The accumulated percentages of *Separated, Divorced, and Widowed* were multiplied by the number *Enrolled in School* - and under the age of 18 - in each community: this figure was then divided by the *Total Population* to determine the *Percentage of Unattended Children* in each community.

Response

The response analysis was intended to quantify the speed and weight of attack by answering the following questions:

- 1) How long does it take to get to the first unit to an incident?
- 2) How long does it take to get additional apparatus to an incident?
- 3) How large is the supplemental manpower response?
- 4) How often does it all happen?

Average annual call volume was included as an indicator of the frequency and probability of occurrence.

Response was determined by a study of the speed and weight of attack, as determined by average response times for first, second, and third due apparatus, percentage of calls with a PCF response, and the average number of PCFs responding. Response statistics were pulled from a Cal Fire *Crystal Reports* summary of all incidents recorded in the *California All Incident Reporting System* (CAIRS) for MCFD Schedule A fire stations from 01/01/2009 to 09/25/2009 (sample in Appendix F). Each incident was assigned to the closest fire station - not the first apparatus at scene. Only incidents occurring within the normal response areas of stations identified in this study were included.

Response times were based on the difference between *Report Time* and *At Scene Time* for incidents where apparatus were dispatched and arrived at scene. Incidents where apparatus were dispatched and cancelled enroute, or assigned to incidents requiring more than an hour's travel out of their response area were excluded (samples in Appendix G). Annual call volume for each station, and the percentage of calls with a PCF response, were extracted from the MCFD (n.d.) *Workload Indicators* report (Appendix H). Average response times for first due, second due, and

third due apparatus, and the difference between the first and third due, were determined by reviewing the incident response data mentioned above.

Average PCF Response Rates were determined by studying redacted PCF payroll sheets for the months 06/2008 through 06/2009 for each of the stations included in this study. The number of PCFs listed on each worksheet was divided by the number of calls on the worksheet to establish an average PCF response, as an indication of available manpower (samples in Appendix I). Since this method only accounted for the average number of PCFs responding on incidents with a PCF response, this figure was then multiplied by the *Percentage of calls with a PCF Response* to identify the supplemental manpower response that could be reasonably expected.

Firefighter Injury Rates

Firefighter injury rates for career personnel were determined by examining redacted worker's compensation reports for the years 2007 and 2008 obtained from the Personnel office at MMU headquarters. *Firefighter injury rates* for PCFs were determined by examining redacted worker's compensation reports for the same time period obtained from the MCFD headquarters office. Of the stations included in this study, there was only one lost time injury reported among career staff, and only one of the three PCF injury reports was for a significant injury. Due to insufficient data, firefighter injury rates were excluded from further analysis.

Demand Zones

Demand zones were determined by plotting incident locations, as determined in the Crystal Reports summary listed above to DeLorme *Street Atlas USA 2010 Plus* (2009), with map files for each fire station viewed separately (Appendix J). A 2.5 mile radius was determined by using *Free Map Tools* and manually transposed into DeLorme (2009). Incident locations outside

the radius were counted, and divided by 75% of the 2008 call volume for each station to determine the percentage of calls within 2.5 miles of each station. The results were used to confirm the validity of the 2.5 mile radius used in the risk assessment (Fig. 2).

Stations	Percentage of calls within a 2.5 mile radius
61	89%
62	81%
64	95%
74	93%
75	83%
76	94%
83	69%
91	96%
92	88%
95	91%
Average	88%

Fig. 2

The data obtained from this aspect of the study had limited applicability for the remainder, and was excluded from the decision matrix.

Apparatus Utilization

Apparatus utilization rates were determined by the aggregate time that apparatus were committed to incidents within each station's initial response area (Appendix G). Times were based on the difference between *Report Time* and *Available Time* for incidents where apparatus were dispatched and arrived at scene, or were dispatched and cancelled enroute. This time element was included as an indication of the frequency and severity of incidents, and the availability of supplemental manpower. The sum total hours, minutes, and seconds for each station were multiplied by 1.25 to determine an *Estimated Annual Apparatus Utilization Rate*.

Apparatus mileage reports were obtained for the year 2008, but the use of reserve apparatus during maintenance, closest-available-unit dispatch protocols, and move-up-and-cover assignments made this data statistically invalid. This author was unable to track mileage by station, and the mileage data was excluded from further analysis.

Limitations noted

Questionnaires were distributed both directly and indirectly, through the California Fire Chiefs Association (CalChiefs) email address list in early August, 2009. Approximately ten percent of the firefighting agencies with jurisdictions in California responded to the questionnaire. An attempt was made to obtain information from as many of these agencies as possible, with the intent of paring the results down to agencies most similar to the MCFD. The poor response rate made this impossible. The respondents in no way constitute a representative sample of fire departments in California, or a fair comparison to the MCFD. The information gathered was included in this study as a reference.

The latest Census Bureau data available for Merced County is almost 10 years old. The pending 2010 census may provide fresh insight into the risk factors identified in this study. Stations 61 and 62 are within the same zip code area, and Stations 75 and 76 are within the same zip code area; therefore they share socioeconomic data sets.

Incident information was gathered for the months January through September, 2009. Projections for the full year were based on an analysis of that data.

Several of Merced County's fire stations are poorly located (e.g. not within their jurisdiction, on the edge of their response area, and/or overlapping response areas) which may skew further risk assessment data conducted in accordance with the procedures used in this study.

Definition of terms

Apparatus: Fire service emergency response vehicles.

Closest-available-unit dispatch: Refers to the practice of dispatching apparatus by location and estimated arrival time. MMU utilizes a GIS-based map system to determine the closest available units. This protocol contrasts with the historical practice of dispatching apparatus by clearly-defined response areas or zones.

Demand Zone: Areas of concentrated calls for service, identified by plotting incident locations on a map.

Draw down: Refers to incidents where the number and type of apparatus available for dispatch are at or below a predetermined minimum threshold, compromising the department's ability to meet minimum service levels.

Engine Company: The terms engine company, company, station, and fire station, are used interchangeably in this document. Each MCFD fire station only houses one engine company.

Geographical Information System (GIS): A collection of computer hardware, software, and data – typically used in the fire service to display and analyze geographically referenced information (GIS.com, n.d., What is GIS?).

Labor/Management agreement: A contractual agreement between an employer and employee group that typically defines wages, hours, working conditions, and other conditions of employment.

Memorandum of Understanding (MOU): See Labor/Management agreement.

Madera, Mariposa, Merced Ranger Unit (MMU): Identifies a geographical or jurisdictional area of Cal Fire operations. MMU is one of 22 Cal Fire Ranger Units in the state of California.

Move-up-and-cover: Refers to the practice of strategically relocating fire apparatus to fill voids created by events that draw down resource levels in specific geographical areas.

Rapid Intervention Team (RIT): Firefighters assigned to this task are responsible for the rescue of other firefighters in the event of a catastrophic event on the fire ground.

Paid Call Firefighter (PCF): Refers to those who are voluntarily involved with fire and emergency services, typically respond from their homes or workplaces, and are only paid for the hours committed to incidents.

Schedule A: Refers to traditional structural firefighting operations within Cal Fire. Schedule A operations typically include city and county fire departments staffed and managed by Cal Fire personnel.

Schedule B: Refers to wildland and forestry firefighting operations within Cal Fire. Staffing at Schedule B stations is often seasonal.

Standards of Response Cover: The CFAI (n.d.) defines this document as a collection of *“policies and procedures [used to determine] the distribution, concentration and reliability of fixed and mobile response forces for fire, emergency medical services, hazardous materials [etc.]... (p. 1).”*

Station: The terms engine company, company, station, and fire station, are used interchangeably in this document. Each MCFD fire station only houses one engine company.

RESULTS

The components included in the decision-making matrix and evaluated in the next phase of this project were: risk assessment, socioeconomics, response, and apparatus utilization.

What value or weight should be assigned to each component of the decision-making matrix?

All combinations of the previously discussed variables and sub-components were first matched in scatter plot analyses to identify correlations that might be used to validate them, assign value, or for use as predictive tools (Appendix K).

Correlations observed between (a) RHAVE scores and *annual call volume*, (b) RHAVE scores and *population*, and (c) RHAVE scores and *apparatus utilization* were strong enough to validate the use of these variables as indicators. These correlations infer that population density can be associated with call volume, and that RHAVE scores are generally indicative of population density.

Correlations between (a) *assessed valuations* and *percent unemployed*, (b) *assessed valuations* and the *difference between first due and third due arrival times*, and (c) *assessed valuations* and *average annual call volume*, were strong enough to validate the use of these variables as indicators. These correlations infer that real estate values can be associated with employment levels, that response times improve in relation to real estate values, and that call volume increases with real estate values. Further inferences drawn from these observations were that higher unemployment levels are common to less populated areas, and that Merced County's engine companies are generally located near the population centers that they serve.

Correlations observed between (a) *call volume* and *education level*, (b) *call volume* and *percent college educated*, (c) *call volume* and *percent below poverty*, (d) *call volume* and *percent enrolled in school*, and (e) *call volume* and indicators of *parental presence*, were strong enough

to validate the use of these variables as indicators. These correlations infer that less educated, poorer, and younger, populations are more likely to require services from the fire department.

Correlations observed between (a) *call volume* and *average response times for first due apparatus*, (b) *call volume* and the *difference between first due and third due arrival times*, (c) *call volume* and the *percentage of calls with a PCF response*, were strong enough to validate the use of these variables as indicators. There was also a correlation between first due and second due response times. These correlations infer that busier companies tend to be located in higher demand areas and are more likely to benefit from a PCF response.

Although these observed correlations were strong enough to verify the validity of the components assigned to the decision matrix, none were strong enough to be considered viable for further statistical analysis. There was a strong correlation observed between *average annual call volume* and *apparatus utilization rates*, which merely inferred that busier engine companies spend more time committed to emergency incidents.

The results of multiple regression studies were inconclusive and forced this author to approach the challenge of assigning value to each component from a different perspective. After reviewing the scatter plot representations for patterns and correlations, it became apparent that the solution was in the outliers. Descriptive statistics were used to identify the mean and standard deviation of each variable group, and mathematically describe how far above or below the median each station's results fell in comparison to the others. Applying a simplified version of statistical technique called *bootstrapping*, the mean was subtracted from each individual value, and the result was divided by the standard deviation to determine the relative value of each result. These relative values indicate how far above or below the norm each result fell.

What combination of these components and respective values will accurately identify the most effective use of available staffing?

The goal of this project was to determine where one additional firefighter would produce the greatest benefit to the department. A total of 15 factors were included in the decision matrix, and grouped into 4 categories, in order to ensure that the final product was based on a comprehensive analysis of the problem.

The relative values *RHAVE scores* and *assessed valuations* for each station were added together, and the results were transferred to the *risk assessment* column of the decision matrix (Appendix L). This combination was selected in order to more accurately demonstrate the level of risk exposure or responsibility confronting each engine company. For example, Company 62's RHAVE score does not adequately reflect their risk exposure or responsibility levels - this Company provides ARFF services at Castle Airport. However, their assessed valuation was significantly higher than that of any other engine company in this study.

The relative values (a) *Percent Undereducated*, (b) *Percent Unemployed*, (c) *Percent Living in Poverty*, and (d) *Percent Unattended Children*, were added together. The result was multiplied by the relative value (e) *Population*. This new value was transferred to the *Socioeconomics* column of the decision matrix (Appendix M). The four socioeconomic indicators used in the calculation are all documented indicators of increased fire activity. On a broader plane, this author asserts that these factors are indicative of increased calls for service. *Population* was used as a multiplier to indicate the proportional value of these socioeconomic risk indicators for each zip code area.

The relative values (a) *Average Response Time - First Due*, (b) *Average Response Time - Second Due*, (c) *Average Response Time - Third Due*, and (d) *Average Difference Between First*

Due and Third Due Response Time, were added together to arrive at a (e) *Response Times* value for each station. These four factors were combined to provide a broader perspective on apparatus response times into each response area included in the study.

The relative value (a) *Percentage of calls with a PCF Response* was multiplied by the (b) *Average PCF Response* to arrive at a (c) *PCF Value*. These factors were combined to indicate the number of PCFs that could reasonably be expected to respond to any given incident.

The (a) *Response Times Values* and (b) *PCF Values* were added together. The result was multiplied by the relative value (c) *Average Annual Call Volume*. This new value was transferred to the *Response* column of the decision matrix (Appendix N). *Response times* and *PCF Values* were combined to assign a value to the speed and weight of attack that could reasonably be expected in each response area. *Call Volume* was used as a multiplier to indicate the frequency of occurrences.

The relative values, *Total Apparatus Hours Committed*, were transferred to the *Apparatus Utilization* column of the decision matrix (Appendix O). This variable was viewed as an indicator of the frequency and severity of incidents, associated workload occurring within each response area, and as a way to value the assistance received from mutual aid or automatic aid agreements. Apparatus responding from other agencies were not included in internal incident response reports. It can be inferred that assistance from outside agencies is reflected in the apparatus utilization figures by reducing the total apparatus hours in this column.

The results from these four columns were then added together to provide a comparative value for each station (Appendix P). The final results - a combination of risk and workload indicators – were then ranked highest to lowest to arrive at a prioritized list that indicates which stations would benefit the most from additional staffing.

The formulas and calculations used to produce this staffing decision matrix (Appendix Q) were then imbedded in an Excel spreadsheet program (Appendix R) and submitted, along with this research paper, to Merced Division Chief Newman for evaluation and further disposition.

DISCUSSION

The components of a decision-making matrix are: context, objective, options, and criteria. (Sorach, 2000). The context of this research project was MCFD Schedule A fire stations, excluding the Atwater City contract stations and the Merced Division's one Schedule B fire station. The objective of this research project was to develop a decision matrix that could be used to objectively prioritize incremental staffing level increases at the engine company level - not to determine what appropriate staffing levels might be. This is in agreement with assertions made by Chief Vickery and Assistant Chief Armstrong that fixed minimum staffing levels are not an efficient or effective way to utilize available resources (Fire Engineering, 1969).

In response to Ronnie Coleman's (1988) appeal to the American fire service to apply scientific principles to the discipline of fire science, this author incorporated risk indicators and risk predictors that had been previously validated by scientific study and accepted by the fire service industry. These were then blended with the loose industry consensus standards discovered during research and deemed applicable.

The options were numerous and included: (a) a risk assessment, (b) the internal fire department analysis associated with accreditation, (c) a study of socioeconomic risk indicators, (d) call volume, (e) response times, (f) demand zones and response area overlap, (g) PCF response rates, (h) a review of Merced County's (2004) *Standards of Response Cover* document, (i) workload indicators such as time to complete certain tasks or time committed to certain tasks, (j) an evaluation of firefighter and civilian fire injury and fatality rates, (k) fire loss statistics, (l) apparatus utilization rates, (m) asset valuations, (n) simultaneous calls for service, and (o) external political pressure.

The criteria used for selection was: (a) sufficient data and supporting documentation, (b) scientifically or statistically proven risk indicators, (c) relevance, and (d) industry-accepted standards.

In a decision matrix, key elements are first identified and then weighted numerically (Time-Management-Guide.com, 2005). The key elements identified for this project were: (a) risk assessment, (b) special projects, (c) socioeconomic risk indicators, the (d) speed and weight of response, (e) firefighter injury rates, (f) demand zones, and (g) apparatus utilization. This author believes that the Fire Service Accreditation process should be addressed as a separate project, as should the development of the MCFD's *Standards of Response Cover* document.

Special projects, time-to-task-completion studies, demand zones, firefighter injury rates, simultaneous calls for service, and political pressure were excluded from the decision matrix because they failed to satisfy all of the criteria requirements. While time-to-task-completion studies may be of some value as an indication of the value of additional staffing, this author was unable to locate any studies that compared timed evolutions between one and two personnel, and was unable to quantify this value. Although the demand zone analysis was useful as a tool to validate the selected risk assessment and assessed valuation radii, the information was not relevant to the decision matrix beyond this point. Firefighter injury statistics from the MCFD were inadequate for further analysis in this study, although it is likely that statistics from a larger database could be used to confirm the relationships between firefighter injury rates and staffing levels reported by Varone (2008) and Vatter (1998).

The issue of simultaneous calls for service was not evaluated on its own due to local dispatch protocol. In the MCFD system, the closest available unit is dispatched, many engine companies are able to staff a second engine with PCF responders for additional incidents within

their response area, and engine companies are strategically relocated in “move up and cover” assignments during localized periods of drawdown. This author was also unable to measure or quantify the effects of political pressure.

In contrast with Assistant Chief Armstrong’s valuation of special projects (Fire Engineering, 1969), this author found that virtually all of the special projects identified in this study could be transferred to any other engine company. Fire loss statistics from incident reports were excluded because they represent rough estimates instead of hard data - they are primarily a result of socioeconomic and environmental factors, and response times (FEMA, 1997; Mission Research Corporation, 1976), which were evaluated elsewhere in this study.

Risk can be defined as “the product of probability and consequence (The Fire Cover Review, 2002, p. 10). The subcomponents selected for the risk analysis were: RHAVE scores and assessed valuations. Time constraints forced this author to limit the RHAVE study to a .25 mile radius around each station, although a demand zone analysis confirmed the validity of a 2.5 mile radius for assessed valuations and future RHAVE analysis.

RHAVE was designed as an evaluative tool that could be used for an indexed risk exposure comparison, and as a reference for decision-making in the fire service (Coleman, 2004; NFA, 2001; ICMA, 2009). This author found the addition of Homeland Security considerations included in the 2001 version of RHAVE a useful way to quantify the additional risk exposures presented by certain target hazards in the community (Holmerud, personal communication, August 25, 2009). Until a better program is released and RHAVE is no longer identified as a viable risk assessment tool, this author believes that the program will retain its usefulness and relevance (ICMA, 2009).

In observance of Glenn's (1990) assertion that risk assessment should not be focused on the "rare, catastrophic event (p. 9, para. 1)," and the *Chief Officer's Desk Reference* (2006) emphasis on "frequency and probability of occurrence (p. 90, para. 1)," this author conducted a comprehensive risk analysis that included every developed parcel within .25 miles, and all target hazards identified in pre-fire plans and within 2.5 miles of each station. It is anticipated that RHAVE scores from a 2.5 mile radius will strengthen many of the correlations observed and discussed above

The subcomponents selected for the socioeconomic risk indicators variable, as identified by the authors of *Socioeconomic Factors and the Incidence of Fire* (FEMA, 1997) were: parental presence, poverty, education levels, and employment rates. Statistics were obtained from the latest U.S. Census Bureau data available for each response area, by zip code. Despite the age of these figures, the limited amount of incident response data evaluated, and the small-scale risk analysis used for this study, moderately strong correlations were observed. This author anticipates that much stronger correlations will be observed when 2010 census figures are released, and compared against the results of full-scale risk analyses.

The subcomponents of the response variable were selected with the intent of assigning value to the speed and weight of attack. Average response times for first due, second due, and third due apparatus, and the average difference between first due and third due response times, were analyzed to answer the questions: 1) How long does it take to get to the first unit to an incident, and 2) how long does it take to get additional apparatus to an incident? PCF response rates, as determined by the percentage of calls with a PCF response and the average number of PCFs responding, were evaluated to answer the question: 3) How large is the supplemental manpower response?

The process used in this analysis was in agreement with the recommendations of CFAI (2003), to consider the value of converging response areas, and the *Chief Officer's Desk Reference* (2006) recommendations that “the frequency and probability of occurrence (p. 90, para. 1)” should be considered. This analysis is also in agreement with ICMA (2002) recommendations that staffing decisions should be considered, in part, on response distance and workload. Response time is closely associated with travel distance, and because fire grows at an exponential rate, extended response times are also an indication of workload - suppression of larger fires is more labor-intensive than suppression of smaller fires. The presence or absence of supplemental manpower that may be reasonably expected at an incident is also indicative of workload for the engine company.

Webb (1994) observed that using fewer firefighters to complete a task extends the time needed to complete the task, and increases risks for both firefighters and civilians, alike. In comparison with the ISO (1980) rating formula for volunteer responders, and in consideration of Webb's (1994) lament that the staggered arrival of PCFs on an incident is not captured in incident statistics, the PCF values used in this matrix may be overvalued. Despite these detractions, this author believes the figures used in this study still provide valid comparative values.

Apparatus utilization was determined by estimating the aggregate sum of hours, minutes, and seconds that apparatus are committed to incidents. This data was extracted from a 9-month incident response report for the MCFD *Schedule A* engine companies. Apparatus utilization, as calculated in this study, reflected recommendations from CFAI (2003), and Shelley (2008), to calculate the amount of time an apparatus is not available for dispatch. This author believes that the method selected in this study also provides an accurate reflection of the interdependency

between stations, and the workloads experienced by each, in observance of CFAI (2003) and ICMA (2002) recommendations.

Assigning weights or values to these factors was a difficult process. A process called bootstrapping was used to assign a relative value to each subcomponent that reflected comparative levels of risk and workload. The relative values of RHAVE scores and assessed valuations were added, and the sums were effectively valued as 25% of the total decision matrix score. The relative values of each of the four socioeconomic risk indicators were multiplied by the relative value of the corresponding population to assign a comparative weight to each collection of risk indicators. This figure was effectively valued as 25% of the total decision matrix.

The relative values, *Percent of calls with a PCF Response* and *Average PCF Response*, were multiplied and added to the sum of the comparative values of each of the four response time variables. The result was multiplied by the relative value *Average Annual call Volume* to assign a comparative weight to the score that reflected the frequency of occurrence. This total was effectively valued as 25% of the total decision matrix.

The relative values assigned to *Apparatus Utilization* were viewed as a combination of workload and risk indicators, and were effectively valued as 25% of the total decision matrix.

Total scores from the decision matrix were then used to highlight the engine companies that would benefit the most from additional staffing (Time-Management-Guide.com, 2005). This process is in agreement with the MCFD (2004) goals: (a) providing cost-effective fire protection and emergency services, and (b) the continual improvement of operational efficiency.

In the absence of accepted industry standards on the topic, this research project may provide guidance and direction for the development and refinement of guidelines for staffing

decisions, in support of USFA (2009) goals to “improve local planning and preparedness,” and “improve the fire and emergency services’ capability for response to and recovery from all hazards.” The implementation of this decision matrix within the author’s organization will provide Merced County with a comprehensive, standardized process for the prioritization of staffing level changes at the engine company level, and may serve as an agency and industry-wide resource for future case studies on the issue.

RECOMMENDATIONS

In observation of NFPA 1710's standards for response times, the MCFD should conduct detailed risk analyses in a five minute response radius around each of its fire stations, as determined by the analysis of incident response locations. In instances where stations are poorly located, the location and radius used for risk assessment and assessed valuations should be determined by an analysis of incident response locations and average response times. The area identified should incorporate at least 80% of call volume. This author estimates that each engine company risk assessment could be completed in a month. Assigning the task of risk assessments to station personnel will ensure that intimate knowledge of each response area is included in the final product.

The MCFD should continue to improve the quality and accuracy of its pre-fire plan database. This data base, and the risk assessment data base, should be periodically audited to ensure accuracy and completeness.

The MCFD should begin tracking average PCF response rates on incidents with a PCF response, as well as the percentage of calls with a PCF response, to more accurately measure the supplemental manpower response that may reasonably be expected on any incident.

The MCFD should engage in the fire service accreditation process, develop its own *Standards of Response Cover* document, and update its Master Plan.

Cal Fire, as the largest fire department in California and the third largest fire department in the United States, should spearhead the development of an American version of the British FSEC Toolkit, in partnership with organizations including the USFA, NFA, CFAI, and CPSE.

The MCFD, and the Cal Fire Academy, should conduct timed evolutions to quantify the value that one additional firefighter brings to a variety of fire ground tasks.

Due to the size and scope of its operations, Cal Fire should conduct an agency-wide risk assessment to determine if various staffing levels have any influence over firefighter injury rates, and motor vehicle accident rates.

The unavailability of a fully-functional risk assessment program begs the need for the rapid development and release of a new risk assessment tool. CPSE should accelerate the development and release of their new product to the American fire service.

This prototype decision matrix should be submitted for agency and industry-wide review, and implemented locally to provide data for future analysis. The lack of industry standards and guidelines on the issue, and the fiscal pressure currently facing most fire departments in America, begs the need for further development. Statistics from the 2010 census should be evaluated as soon as possible to confirm the validity of correlations inferred in this study.

Although the influence of external political pressure, and strategic needs unique to the local level cannot be overlooked, the value and validity of this decision-making matrix can only be established through the repeated implementation, review, and analysis of the results. This matrix can only be refined through critique and the analysis of results obtained in multiple case studies.

REFERENCES

- Allcott, B. (1991). *Manning Level Impact on Initial Fire Attack*. Emmitsburg, MD: National Fire Academy.
- Allora, M. (Dec. 2003). In Fire Engineering Magazine. *Roundtable*. Vol. 156, No. 12.
- Armstrong, V. (June 1969). In Fire Engineering Magazine. *The Round Table*. Vol. 122, No. 6.
- Cal Fire Intranet (n.d.). Outlook: Public Folders: All Public Folders: Southern Region: Madera Mariposa Merced: MMU Merced Division: Prevention: Pre-Plans
- Cal Fire, n.d. *Local Government*. Retrieved August 18, 2009, from http://www.fire.ca.gov/fire_protection/fire_protection_coop_efforts_localgov.php
- CDF Firefighters (n.d.). *Who we are*. Retrieved August 18, 2009, from <http://www.cdf-firefighters.org/who-we-are.htm>
- Clark, W. (Nov. 1960). Time Study Trials of Engine and Ladder Company Evolutions. *Fire Engineering Magazine*, Vol. 113, No. 11.
- Coleman, R. (Feb. 2004). Self-Assessment More Than a Means to an End. *Fire Chief Magazine*, Vol. 48, Number 2.
- Coleman, R. (Feb. 1998). The taxonomy of fire. *Fire Chief Magazine*, Vol. 42, Number 2.
- Commission on Fire Accreditation International, Inc. (2003). *Creating and Evaluating Standards of Response Coverage for Fire Departments*.
- Cooper, S. (1991). *Developing Engine Company Staffing Recommendations*. Emmitsburg, MD: National Fire Academy.
- Daniels, I. (Mar. 2008). At all Costs? *Fire Rescue Magazine*, Vol. 26, Issue 3.
- DeLuca, C. (Aug. 2005). The Engine Company as the Rapid Intervention team. *Fire Engineering Magazine*, Vol. 158, No. 8.

Department for Communities and Local Government (2008). *Analysis of Fire and Rescue Service Performance and Outcomes with Reference to Population Socio-Demographics*.

Retrieved July 20, 2009, from

<http://www.communities.gov.uk/publications/fire/fsperformanceanalysis>

Department for Communities and Local Government (2008). *Fire Service Emergency Cover Toolkit: Executive Summary*. Retrieved July 14, 2009, from

<http://www.communities.gov.uk/publications/fire/fsectoolkit012008>

Department for Communities and Local Government (2008). *Risk Assessment Tools, Techniques and Data for the Civil Contingencies Act and Integrated Risk Management Planning*.

Retrieved July 20, 2009, from

<http://www.communities.gov.uk/publications/fire/riskassessmenttools>

Delorme (2009). Street Atlas USA 2010 PLUS [Computer software].

Federal Emergency Management Agency, United States Fire Administration (2008). *Emergency Incident Rehabilitation*. FA-314.

Federal Emergency Management Agency, United States Fire Administration (1996). *Risk Management Practices in the Fire Service*. FA 166.

Federal Emergency Management Agency, United States Fire Administration (1997). *Socioeconomic Factors and the Incidence of Fire*. FA 170.

The Fire Cover Review (Oct. 2002). *Report of the Task Group to the Central Fire Brigades Advisory Councils*. Retrieved July 20, 2009, from

<http://www.communities.gov.uk/documents/fire/pdf/143771.pdf>

- The Fire Cover Review (Oct. 2002). *Report of the Task Group to the Central Fire Brigades Advisory Councils*. Volume 2 – Technical Papers. Retrieved July 20, 2009, from <http://www.communities.gov.uk/documents/fire/pdf/143726.pdf>
- Fire Engineering Magazine (Mar. 1969). *The Round Table*. Vol. 122, No. 3.
- Fire Engineering Magazine (Apr. 1969). *The Round Table*. Vol. 122, No. 4.
- Free Map Tools (n.d.). Accessed at <http://www.freemaptools.com/radius-around-point.htm>
- GIS.com (n.d.). What is GIS? Retrieved January 03, 2010 from <http://www.gis.com/content/what-gis>
- Glenn, G. (1990). *Suppression Company Staffing Levels on Their Impact on Operations*. Emmitsburg, MD: National Fire Academy.
- Goldfeder, W. (Jan. 2009). Maine Firefighter Trapped: Part 2 – The Post-Incident Analysis. *Firehouse Magazine*, Vol. 34, No. 1.
- Google Maps (n.d.). Accessed at <http://maps.google.com/>
- Insurance Services Office (1980). *Fire Suppression Rating Schedule*.
- International Association of Fire Fighters (1995). *Safe Firefighter Staffing – Critical Considerations* (2nd Ed).
- International Association of Fire Chiefs (2006). *Chief Fire Officer's Desk Reference*. Buckman, J., ed. Sudbury, Massachusetts: Jones and Bartlett.
- International City/County Management Association (2002). *Managing Fire and Rescue Services*.
- International City/County Management Association (2009). *Managing Fire and Rescue Services*.
- Kistner, D. (Dec. 2003). In Fire Engineering Magazine. *Roundtable*. Vol. 156, No. 12.
- Malloy, J. (June 1969). In Fire Engineering Magazine. *The Round Table*. Vol. 122, No. 6.

Merced County Association of Governments (n.d.). GIS: Interactive Maps. Accessed at

<http://www.mcaggis.com/Map.htm>

Merced County Fire Department (n.d.) website. Retrieved August 17, 2009, from

<http://www.co.merced.ca.us/index.aspx?NID=70>

Merced County Fire Department (2004). *A Blueprint for the Future: A Master Plan for the Continued Success of the Merced County Fire Department*.

Merced County Fire Department (n.d.). *Merced County Fire Department Workload Indicators*.

Mission Research Corporation (1976). *Program for the Establishment of the Relative Effectiveness of Alternative Personnel Complements for Engine and Truck Companies Engaged in Fire Suppression Operations*. MRC Report No. 7634-1-476A.

Morrison, R. (n.d.). *Manning Levels for Engine and Ladder companies in Small Fire Departments*. Emmitsburg, MD: National Fire Academy.

National Fire Academy (2006). *Executive Development – Student Manual (3rd Ed)*.

National Fire Academy, Commission on Fire Service Accreditation International (2001). FA 213. *Risk, Hazard and Value Evaluation*. Installation and User's Manual.

National Fire Protection Association 1500 (2007). *Standard on Fire Department Occupational Safety and Health Program*.

National Fire Protection Association 1710 (2004). *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Departments*.

Shelley, C. (2008). *Critical Factors and Staffing Options for the Deployment of an Additional Ambulance Within the Colleyville Fire Department*. Emmitsburg, MD: National Fire Academy.

- Sorach, Inc (2000). *Decision-Making Fundamentals*. Retrieved September 2, 2009, from <http://www.sorach.com/decision.html>
- Time-Management-Guide.com (2005). *How to use a Decision Matrix to Streamline Your Decision Making Process*. Retrieved September 2, 2009, from <http://www.time-management-guide.com/decision-matrix.html>
- Urbano, P. (Apr. 2008). Dedicated Company Assignments: Some Q's and A's. *Fire Engineering Magazine*, Vol. 161, No. 4.
- United States Census Bureau (n.d.). *American Fact Finder: Fact Sheets*. Retrieved from http://factfinder.census.gov/servlet/ACSSAFFacts?_submenuID=factsheet_0&_sse=on
- United States Fire Administration (2009). *Popular searches*. Retrieved August 18, 2009, from http://www.usfa.dhs.gov/help/popular_requests.shtm
- United States Fire Administration (2009). *Strategic Plan*. Retrieved July 10, 2009, from <http://www.usfa.dhs.gov/about/strategic/>
- Varone, C. (1995). *Providence Fire Department Staffing Study Revisited*. Emmitsburg, MD: National Fire Academy.
- Vatter, M. (1998). *Firefighter Safety: An Inferential Analysis of the Relationship Between Staffing Levels, Fire Severity, and Injuries*. Emmitsburg, MD: National Fire Academy.
- Vickery, G. (May 1969). In *Fire Engineering Magazine. The Round Table*. Vol. 122, No. 5.
- Webb, J. (1994). *Report on Engine Company Staffing*. Emmitsburg, MD: National Fire Academy.